Szczecin, Poland, 30.12.2024

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Study of phase transformations in nanocrystalline iron nitrides with specific size of crystallites

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ABSTRACT

Nitriding of iron and steel has been utilized for over a hundred years to enhance the properties of materials subject to extreme conditions. Currently, due to their exceptional properties, the application of nanomaterials from the iron-nitrogen system is sought in soil and water remediation, catalysis and electronics.

The first part of the dissertation is an introduction to the subject of the Fe-N system, in particular with limited characteristic dimensions, a discussion of the basics of the utilised research methods and a description of the methodology that could be used to determine the characteristic dimensions of materials.

The literature on the subject indicates, that changing the characteristic dimensions of the material subjected to nitriding significantly affects the conditions of the process necessary to obtain a specific crystalline phase. Despite decades of research, information on the differences in the nitriding mechanism between bulk and nanocrystalline materials is not complete.

The second part of the dissertation focuses on the discussion of the research methodology. In the presented study, *in situ* methods such as X-ray powder diffraction and thermogravimetry, supplemented by *ex situ* electron microscopy imaging, X-ray microanalysis, electron diffraction and chemical composition analysis methods were used. The nitriding and denitriding processes in materials with different crystallite sizes and size distributions within the range adopted for nanocrystalline materials were systematically studied. The focus was on the analysis of reaction states considered quasi-stationary.

The results of the research presented in the dissertation allowed to confirm a number of observations that were previously reported on the nitriding and denitriding of nanocrystalline iron and its nitrides. The utilised approach allowed to observe nuances that had been omitted so far, which were discussed in detail.

The main novelty of the presented study is to draw attention to and present experimental evidence for the existence of the phenomenon of phase boundary coherence during transformations in the Fe-N system. This phenomenon is associated with the existence of a coherency strain that affects the Gibbs energy of the system. Therefore, there are differences in the nitriding potential required for transformations in materials with different crystallite sizes. In particular, this phenomenon is the main reason for the occurrence of hysteresis between nitriding and denitriding processes in the nanocrystalline iron-nitrogen system.

Keywords:

Nanomaterials, iron nitrides, phase transformations, crystallite size, phase boundary coherency

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